THE INFLUENCE OF THE AGE OF PARENT AT BIRTH OF OFFSPRING UPON THE DEVELOPMENT OF EYE COLOUR AND INTELLIGENCE—A CORRECTION.

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Owing to some regrettable slips in the arithmetical work of the paper dealing with eye colour and intelligence recently published in this *Journal*[1] several of the constants are inaccurate. The whole of the calculations have now been re-worked and the correct values are given below. I have incorporated some fresh material, the analysis of which somewhat strengthens the conclusions already published.

I shall first discuss the new material. Table I records the eye colour distributions of infants aged from one to six months by categories of parental age and the resultant correlation. Although the estimated probable error, derived by the formula appropriate to product moment correlations, is not a complete measure of the random fluctuations of such coefficients as these, the relation found would appear to be of some significance and is actually the largest yet obtained from material of this class.

An obvious criticism is that the age distribution of the infants may be materially different for different arrays of parents. To test the importance of this, an extended series of observations was made upon children, from birth

Table I.

Influence of Age of Parent at Birth and Eye Colour of Young Infant (one to six months of age). (Barking.)

	Eye colour. Infant.			
Age of Parent	Blue	Not blue	Total	Percentage not blue
16th to 20th years	16	0	16	0
21st „ 24th „	59	6	65	9·2
25th „ 28th „	65	13	78	16·1
29th „ 32nd „	55	12	67	17·9
33rd „ 36th „	34	7.	41	17·1
37th „ 40th „	35	12	47	25·5
41st „ 44th „	10	2	12	16·6
Totals	274	52	326	

$r = +{\cdot}206 \pm {\cdot}036.$

[1] *Journ. of Hygiene*, XVI. 1917, pp. 12–35.

to the age of one year, the material being derived from an infant clinic (Tables II–IV). The resulting constants are:

Standard Deviation, Mother's Age	1·5894 ± ·0386
„ „ Child's „	2·9905 ± ·0726
Correlation of Child's Eye Colour and Mother's Age ...	·115 ± ·035
„ „ „ „ Child's „ ...	·348 ± ·030
„ „ Age „ Mother's „ ...	·034 ± ·035

Hence the partial correlation of mother's age and child's eye colour. Child's age constant

$$r = \cdot 110 \pm \cdot 034.$$

Table II.

Child's Age and Mother's Age.

Child's age in weeks	Mother's age in years: 16–20	21–24	25–28	29–32	33–36	37–40	41–44	45–48	Totals
1–4	3	11	11	8	5	5	2	—	45
5–8	7	23	20	26	15	14	5	1	111
9–12	3	12	15	8	9	11	1	—	59
13–16	2	7	10	7	4	6	2	—	38
17–20	2	1	14	8	4	3	1	—	33
21–24	—	6	6	6	4	3	—	—	25
25–28	1	5	4	2	3	2	2	—	19
29–32	1	7	5	2	3	3	—	—	21
33–36	—	—	—	—	1	3	—	1	5
37–40	—	2	3	1	2	—	—	—	8
41–44	—	—	2	1	—	—	1	—	4
45–48	—	2	1	4	2	—	—	—	9
49–52	1	1	1	2	2	2	—	—	9
	20	77	92	75	54	52	14	2	386

Table III.

Child's Age and Eye Colour.

Child's age in weeks	Child's eye colour: Blue	Not blue	Total
1–4	43	2	45
5–8	103	8	111
9–12	51	8	59
13–16	24	14	38
17–20	23	10	33
21–24	21	4	25
25–28	14	5	19
29–32	19	2	21
33–36	2	3	5
37–40	4	4	8
41–44	3	1	4
45–48	4	5	9
49–52	7	2	9
	318	68	386

Table IV.

Child's Eye Colour and Mother's Age.

Age of mother in years	Child's eye colour Blue	Not blue	Total
16–20	20	—	20
21–24	66	11	77
25–28	74	18	92
29–32	60	15	75
33–36	45	9	54
37–40	39	13	52
41–44	12	2	14
45 and over	2	—	2
	318	68	386

It appears therefore that some weight must be assigned to the objection offered but that when it is allowed for correlation persists.

In Table V the age of the father is taken into consideration. Information on this point being obtained indirectly through the mother, it is doubtless not very accurate. The correlation, of the same order of magnitude as found for the mother and child, rather suggests that any biological significance attaching to the previous results is not dependent upon intra-uterine nutritive changes.

Table V.

Age of Father at Birth of Child. (Children under 1 *year when observed.)*

Father's age in years	Children's eye colour Blue	Not blue	Total
16–20	1	—	1
21–24	29	6	35
25–28	64	12	76
29–32	67	12	79
33–36	37	11	48
37–40	42	13	55
41–44	19	5	24
45–48	15	4	19
49–52	4	1	5
53–56	1	1	2
57–60	2	—	2
	281	65	346

Standard Deviation, father's age, 1·849.
Coefficient of correlation, $r = \cdot 0924 \pm \cdot 036$.

I now pass to the correction of previously published results. The numbering of the tables is that of the paper cited.

Middlesbrough School Children (younger).

		Boys	Girls
Tables VIII and VII.	Age of parent at birth and eye colour ...	$r = \cdot 138 \pm \cdot 032$	$\cdot 048 \pm \cdot 032$
,, X and IX.	Age of parent at birth and child's eye colour	$r = \cdot 149 \pm \cdot 032$	$\cdot 071 \pm \cdot 032$
,, XI and XII.	Eye colour, mother and child	$r = \cdot 524 \pm \cdot 024$	$\cdot 623 \pm \cdot 019$

Making the Third Factor Constant in Each Case.

	Boys	Girls
Tables VIII and VII.	$r = \cdot 070 \pm \cdot 033$	$\cdot 046 \pm \cdot 032$
„ X and IX.	$r = \cdot 092 \pm \cdot 032$	$\cdot 053 \pm \cdot 032$
„ XI and XII.	$r = \cdot 514 \pm \cdot 020$	$\cdot 622 \pm \cdot 019$

Barking School Children (*older*).

Table II.	Eye colour, mother and child	$r = \cdot 608 \pm \cdot 020$
„ III.	Age of parent at birth and child's eye colour	$r = \cdot 005 \pm \cdot 032$
„ IV.	Age of parent at birth and her own eye colour	$r = \cdot 009 \pm \cdot 034$

Making the Third Factor Constant in Each Case.

Table II.	$r = \cdot 607 \pm \cdot 020$
„ III.	$r = \cdot 001 \pm \cdot 034$
„ IV.	$r = \cdot 008 \pm \cdot 032$

Random Observation.

Table V.	Eye colour of any mother with any child but its own	$r = \cdot 030 \pm \cdot 072$
„ V.	Age of parent at birth with eye colour of any child but its own ...	$r = -\cdot 068 \pm \cdot 026$

Adult Life.

Table XIII.	Age of grandmother at birth of mother and mother's eye colour	$r = \cdot 003 \pm \cdot 022$
Table XIV.	Represents Tables VII and VIII taken together and refers to mother's eye colour only, that is, "Age at birth and her own eye colour"	$r = \cdot 093 \pm \cdot 022$

Taking the chief constants we have:

1.	Young infants	$r = \cdot 206 \pm \cdot 036$
2.	Young school children, boys ...	$r = \cdot 092 \pm \cdot 032$
	„ „ „ girls ...	$r = \cdot 052 \pm \cdot 032$
3.	Older school children	$r = \cdot 001 \pm \cdot 034$
4.	Adults	$r = \cdot 003 \pm \cdot 022$

From these figures it is seen that the value of r obtained in samples of a young infant population disappears or becomes very small in sampling older children. In the younger school children the correlation for girls is not significant, for boys it may be so and therefore may indicate some bias. Hence I suggest that the rate of change of eye colour is more rapid in the later born, and that of the two sexes, the boys are probably somewhat later than the girls in reaching the full development of pigmentation.

If the development of shade, from the primitive blue of birth, is studied, it would seem that none of the ultimate colours can be regarded as transitional stages, hence if a scale could be devised, blue must occupy the middle position, the brown being towards one end and the grey towards the other. Or rather the primitive blue in the centre and the resultant colours occupying some position on the surface of a sphere. Hence there may be some justification for the division of eye colour into three groups, grey, blue and brown, and for treating them as though the distribution were Gaussian.

If this assumption *is* justifiable, then we may arrange our data in the following way, taking first the question as to whether there is a significant

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difference in distribution of eye colour in those women who reproduce before and after the 30th year.

Reproducing Women.

Age	Brown	Blue	Grey, etc.	Totals
40 years and under at time of observation	246 (33·5)	234 (31·9)	253 (34·5)	733
41 years and over at time of observation... ...	181 (30·7)	161 (27·3)	247 (41·9)	589
	427	395	500	1322

30 years and under at time of birth, 40 years and under at time of examination.

Distance of brown from $\bar{x}=\cdot 4245$
„ „ grey „ $\bar{x}=\cdot 3988$
$\cdot 8233$

Standard Deviation 1·214 ± ·019.

31 years and over at time of birth, 41 years and over at time of examination.

Distance of brown from $\bar{x}=\cdot 5046$
„ „ grey „ $\bar{x}=\cdot 2035$
$\cdot 7081$

Standard Deviation 1·412 ± ·023.

From this it is seen that there is a slight and perhaps significant difference between the two groups, dependent upon a diminution in the number classed as blue and a large increase amongst the greys. But it must be remembered that the range of age in the latter class is from 41 years to 58 years, and the former from 28 years to 40 years, and that some change is to be expected on that account.

It seems reasonable therefore to suppose that so far as these observations allow, there is no definite evidence of selection with respect to eye colour in a population of reproducing women.

Turning to the school children:

School Children. All ages from 7 years.

Boys and Girls. Eye Colour.

	Brown	Blue	Grey, etc.	Totals
Born at age of 30 years and under	357 (28·4)	582 (46·3)	318 (25·3)	1257
„ „ 31 „ „ over	269 (31·1)	340 (39·3)	256 (29·6)	865
	626	922	574	2122

30 years and under.

Distance of brown from $\bar{x}=\cdot 5715$
„ grey „ $\bar{x}=\cdot 6653$
$1\cdot 2368$

Standard Deviation ·809 ± ·013.

31 years and over.

Distance of brown from $\bar{x}=\cdot 4934$
„ grey „ $\bar{x}=\cdot 5361$
$1\cdot 0295$

Standard Deviation ·9713 ± ·020.

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At least *prima facie*, the distribution deviates from the parental type and in the opposite direction so far as the relation of age to the proportion classed as brown is concerned. I do not, however, desire to put much weight upon constants deduced on an assumption which is somewhat arbitrary.

It has occurred to me that the existence of correlation when parental age is correlated with the eye colours of young children and its evanescence when older children are involved may be a reflection of a phenomenon suggested by earlier results, viz. that the variability of filial arrays increases with the parental age at birth. Given a surface of zero regression but with increasing array variability, truncations of it should exhibit correlation. This may be illustrated in the special case of Gaussian arrays.

Suppose that all x arrays of y are Gaussian and further that every $\bar{y}_x = \bar{y}$. Then the correlations of the two surfaces formed by dividing the original surface by a plane intersecting the axis of y at right angles in the line $y = 0$ are equal and opposite if σ_{y_x} increases with x.

Let $\bar{x}_1$, σ_{x_1}, $\bar{x}_2$, σ_{x_2}, $\bar{y}_1$, σ_{y_1}, $\bar{y}_2$, σ_{y_2} be the means and standard deviations of the two halves, all measurements being from the means.

Then
$$\bar{x}_1 = \bar{x}_2 = \bar{x} = 0,$$
$$\sigma_{x_1} = \sigma_{x_2} = \sigma_x,$$
$$\bar{y}_1 = -\bar{y}_2,$$
$$\sigma_{y_1} = \sigma_{y_2}.$$

Consider the contribution made to the sum product $S_1 xy$ by the array $y_{x=-s}$. It is
$$-\frac{s\alpha_{-s}}{\sqrt{2\pi}\,\sigma_{y_{x=-s}}}\int_{-x}^{0} y e^{-\frac{y^2}{2\sigma^2_{y_{x=s}}}}\,.\,dy = \frac{s\alpha_{-s}\sigma_{y_{x=-s}}}{\sqrt{2\pi}},$$
where α_{-s} is a function of $x = -s$.

Similarly the contribution of the array $y_{x=+s}$ is
$$-\frac{s\alpha_{+s}\sigma_{y_{x=+s}}}{\sqrt{2\pi}}.$$

Thus the contribution of corresponding arrays is
$$\frac{s}{\sqrt{2\pi}}(\alpha_{-s}\sigma_{y_{x=-s}} - \alpha_{+s}\sigma_{y_{x=+s}}),$$
and the complete product
$$\frac{1}{\sqrt{2\pi}} Ss\,(\alpha_{-s}\sigma_{y_{x=-s}} - \alpha_{+s}\sigma_{y_{x=+s}}),$$
for all values of s; while the sum product of the other half is the same expression with signs reversed.

Hence the correlations are equal and opposite.

Consequently a fraction of the whole surface would exhibit correlation absent from a fair sample of the whole surface. Evidently the comparison of

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a sample of young children with one of older children is not a simple case of truncation such as here contemplated, but it seems to me possible that the principle operates.

Intelligence.

The corrected coefficients for intelligence are as follows. They differ considerably from those already given.

Child in Fifth Year (entering school).

				Partial coefficient
Table	XX.	Age of mother at birth of child and her own standard	$r =$ ·060 ± ·027	·079 ± ·027
,,	XXII.	Age of mother at birth and class of child	$r =$ ·029 ± ·024	·024 ± ·028
,,	XXIV.	Standard of mother and class of child ...	$r =$ ·074 ± ·024	·076 ± ·027
,,	XXVI.	Age of mother on leaving school and her own standard	$r =$ ·435 ± ·022	·438 ± ·022
,,	XXVIII.	Age of mother on leaving school and class of child	$r =$ ·010 ± ·028	− ·023 ± ·028
,,	XXX.	Age of mother on leaving school and age at birth	$r =$ − ·031 ± ·028	− ·063 ± ·027

Child in Thirteenth Year.

				Partial coefficient
Table	XXI.	Age of mother at birth of child and her own standard	$r =$ − ·1119 ± ·038	− ·139 ± ·042
,,	XXIII.	Age of mother at birth and standard of child	$r =$ ·110 ± ·041	·155 ± ·042
,,	XXV.	Standard of mother and standard of child	$r =$ ·349 ± ·037	·389 ± ·036
,,	XXVII.	Age of mother on leaving school and her own standard	$r =$ ·415 ± ·035	·430 ± ·034
,,	XXIX.	Age of mother on leaving school and standard of child	$r =$ ·017 ± ·047	− ·146 ± ·047
,,	XXXI.	Age of mother on leaving school and age at birth	$r =$ − ·082 ± ·042	− ·016 ± ·043

The main points are, firstly, that the correlation between the standard of the mother on leaving school at a constant age with the class of the child in its 5th year is significant but very small, and the correlation between the standard of mother at constant age with standard of child at 13th year is very much larger, but not as large as might be expected. This may be due to errors of record or to the fact that the mental characters upon which scholastic intelligence depends, hardly exist at the 5th year and are not even fully developed at the 14th year.

If this explanation is adopted as correct, then intelligence falls into the same category as eye colour, that is to say, at the 5th year the scholastic intelligence of a child corresponds to the eye colour of a new born babe, and hence there is no significant correlation between age of mother at birth and class of child. At the 14th year we are dealing with a period during which intelligence is only half developed, that is to say, our record corresponds to eye colour during the first year and hence a significant correlation is found. Had our record been one dealing with a period of life when intelligence is as fully developed as it ever will be, then in all probability the correlation

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would become insignificant. This assumes that intelligence follows the same lines as the other characters investigated, viz., that the chief effect of age of the uniting germ cells is to produce an increased variability in those upon which the time influence is the greater.

Still the difference between the value of the association between age of mother at birth and her own standard for the 5th year being + ·08 and for the 13th − ·14, definitely suggests that the two series differ in other ways, beyond the fact that the families concerned contain a child in the 5th–13th years. As was previously stated the data are not above suspicion of bias.